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Automatic tree species recognition
with quantitative structure models

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Introduction

- A novel tree species recognition approach from terrestrial laser scanner (TLS) data.

- TLS data dimensionality is increased by reconstructing Quantitative Structure Models (QSM) before classification feature computations.

- Tree species recognised from 15 geometrical and topological classification features derived from QSMs.

- The input of the fully automatic approach is a forest plot level point cloud, the output a collection of detailed 3D models with the species information.

Materials and methods

- Included species:

  B Silver birch
  Betula pendula Roth

  P Scots pine
  Pinus sylvestris L.

  S Norway spruce
  Picea abies [L.] Karsten

- 3 single-species and 2 mixed-species forest plots in Finland with over 1200 trees.

- RIEGL VZ-400 with 0.04 resolution and several scanning positions.

- Retroreflectors & RiScan Pro for registration.

- Trees extracted from TLS data and reconstructed as QSMs automatically.

- Classification methods tested: k-nearest neighbours, multinomial regression, and support vector machines.

Classification features

- Features are robust with respect to tree and branch extraction errors.

Stem branch angle

Crown start height

Cylinder len. / tree vol.

B **P** **S**

#	**Stem branch**
1	Angle
2	Cluster size
3	Radius
4	Length
5	Distance

#	**Crown**
6	Start height
7	Height
8	Evenness
9	Diameter / height

#	**Tree**
10	DBH / tree height
11	DBH / tree volume
12	DBH / min. tree radius
13	Volume below 55 % of height
14	Cylinder length / tree volume
15	Shedding ratio

Results: single-species forest plots

1010 trees from three plots

96% maximum accuracy

30 training samples

10-fold leave-one-out cross validation by dividing data into 10 equal sized bins. One-by-one each bin acted as testing data while the other nine formed the training data.

All classification methods performed well (> 95 %) with some feature combination. Highest accuracy, 96.9 % with the 4-NN method and 10 features.

Training set size was varied in steps from 4 to 150 samples per species. The increase in accuracy after 30 samples was minimal, indicating that as little as 30 training samples per species can be enough.
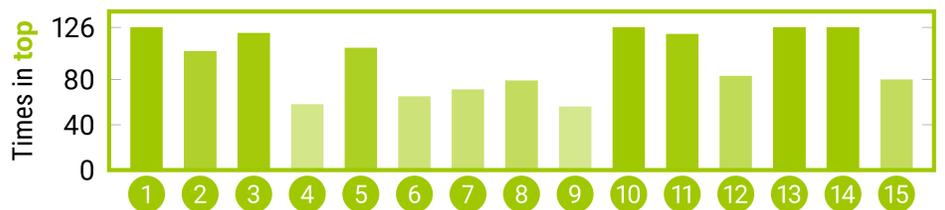
126 **top feature combinations** were identified: average of all methods ≥ 95 %, or minimum of all methods ≥ 94 %.

Results: mixed-species forest plots

Only preliminary testing was possible with trees from mixed-species forest plots due to the lack of comprehensive combined TLS and reference species classification data. 76 % maximum accuracy when using only single-species training data, 81 % when training data was augmented with spruce trees from mixed-species stands. In the latter case accuracy was 91 % for spruce trees that had comprehensive training data.

● single-species
✕ mixed-species

249 trees from two plots

81% maximum accuracy

Further information

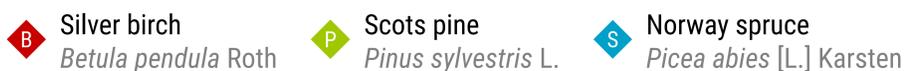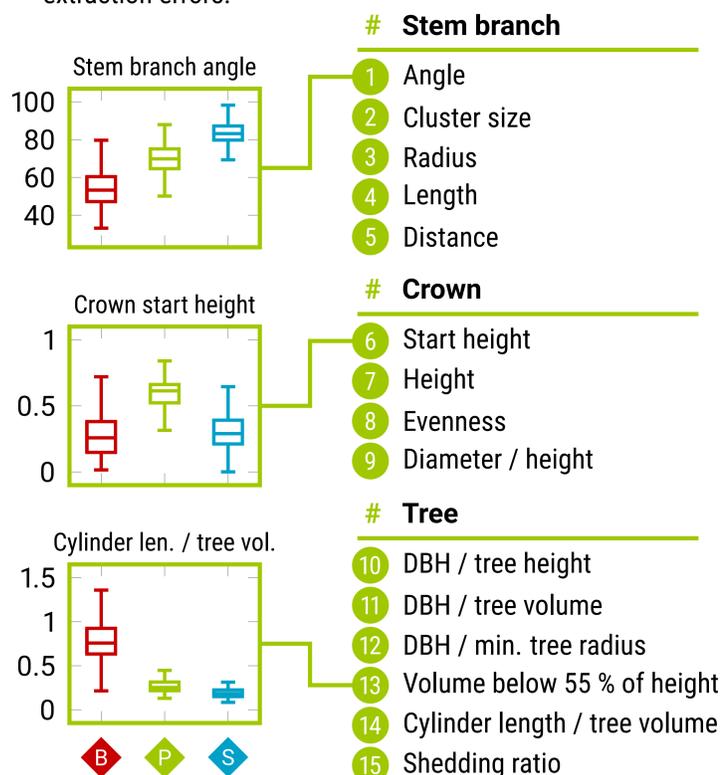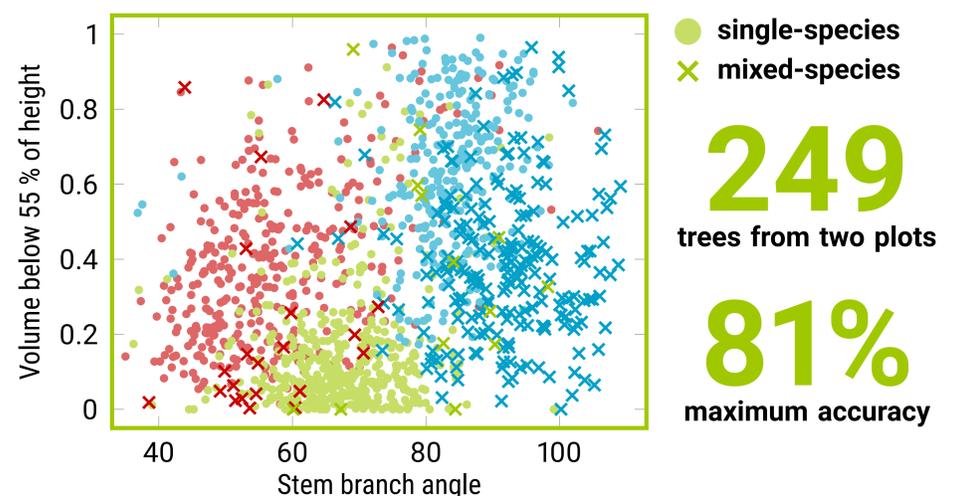Åkerblom, M., Raumonen, P., Mäkipää, R., and Kaasalainen, M. (2017). Automatic tree species recognition with quantitative structure models. *Remote Sensing of Environment*, 191:1 – 12.
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